Utah FOUNDATION

Research Report

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IS THE PRICE FINALLY RIGHT?

THE ECONOMICS OF RENEWABLE ENERGY

HIGHLIGHTS

- Utah energy prices rank 7th lowest among all states and the District of Columbia.
- Utah is an energy exporter, producing 16 million MWh more electricity than it consumes.
- The electricity produced in Utah is largely derived from coal, with smaller contributions from natural gas-fired and hydroelectric plants.
- While Utah is currently taking advantage of some of its renewable resource potential, there is much more available for development.
- Electrical generation from wind has relatively low capacity, able to contribute power to the grid 34% of the time. However, land-based wind farms have no variable operation costs.
- Solar power is the most expensive resource, with solar thermal being particularly costly, due to the moving parts associated with the calibrated mirrors that move with the motion of the sun to reflect the maximum light.
- Geothermal power has a high capacity factor, contributing to the power grid 92% of the time. While capital costs and fixed O&M are relatively high, variable O&M and transmission investments are very low.
- Biomass is another high capacity-factor resource, with the lowest capital costs among renewables. While fixed O&M is lower than most renewable resources, variable O&M is higher, due to the need for constant supplies of biomass fuel.

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During the past several years, there has been a surge of interest among policymakers, scientists, investors and the public alike in renewable energy. The potential of harnessing power derived from virtually unlimited, renewable resources such as wind, the sun, water, the heat of the earth, and even organic matter, is appealing in comparison to using power derived from fossil fuels. The latter include resources such as oil, which must be imported, is scarce, can have drastic price fluctuations, and coal, the use of which results in the emission of carbon dioxide and other elements and compounds.

Once constructed, many renewable energy plants do not require "fuel" to run at all in the traditional sense, only maintenance. However, the benefits of alternative energy come with alternative cost considerations. In order to harness the power of wind, for example, a wind farm must be constructed with large, wind-propelled blades attached to turbines that rotate and produce electricity. Compared to the cost of constructing, maintaining and fueling a coal power plant, along with the more reliable availability of coal to produce power (which, unlike wind, can be on-tap 24 hours a day, 7 days a week), wind power has historically been expensive. On the other hand, the field of renewable energy is dynamic and currently undergoing rapid change in terms of both technological advances and falling prices. This leads to two questions:

1. *What are the comprehensive, or "true," costs of the various types of renewable energy?*
2. *How do these costs compare with the costs of traditional energy resources?*

Knowing the answers to these questions will enable policymakers and the public to intelligently answer the bigger question in relation to renewable energy, which is, *is increasing the share of renewable energy in our energy portfolio a wise strategy for the future?*

COMPARING THE COSTS OF ENERGY

The analysis in this report will focus on comparing energy resources that are used to produce *electricity*. While alternative fuels for automobiles are an important and evolving part of the renewable energy landscape, for the purposes of this report, they will not be discussed here.

Also, while there are quite a number of renewable sources of energy, this report will limit its analysis to the major renewables, including wind (both land-based and off-shore), solar (both photovoltaic and thermal), geothermal, biomass, and hydroelectric. These will be compared to the major, traditional sources of energy, including the various major types of coal and natural gas technologies as well as nuclear energy.

In analyzing the costs of renewable energy and then comparing those costs to traditional energy sources, this report will do a number of things. First, there will be a discussion of each of the major renewable energy resources. This will include a description of each source, along with resource-specific cost and benefit considerations. Factors specific to Utah will also be addressed, as well as factors related to the global political economy of energy. Technological advances and other issues relevant to the current and future costs of renewable energy will also be considered.

Next, renewable energy will be discussed within the context of the energy markets in the United States, as well as in Utah. This will include data on the price of electricity and the amount of energy from renewables versus traditional resources, as well as the potential for renewable energy generation in Utah.

Next, the different costs that should be considered when evaluating and comparing energy sources will be explained in detail. Then actual data on the costs of renewable energy will be compared with data on the costs of traditional energy resources. Doing this will create a basis for comparison of the costs of renewable and traditional energy resources.

Finally, national and state policies that affect the economics of renewable energy will be discussed. These include states' renewable portfolio standards (standards for how much renewable energy a state will produce or consume), federal and state renewable energy incentives, and other policies. An alternative set of Levelized Energy Costs (LECs) that incorporates some of these incentives will also be discussed.

EXPLAINING MEASURES OF ELECTRICITY

Before delving into the details of renewable energy, its costs and benefits, it bears explaining some of the terminology used to describe electricity production. To describe how much electricity a resource is capable of producing and actually produces, as well as how that compares with other sources of electricity, the most common measures are watts, and watt hours. Watts are a unit used to measure power. Watt hours, on the other hand, are a measure of energy, or the amount of power actually produced/consumed over a given amount of time. An easy way to think of this is to think of the average incandescent light bulb, which might be labeled as a "40 watt" or "60 watt" bulb, depending on how bright it is. A 60 watt light bulb turned on for one hour would therefore consume 60 watt hours (Wh) of electricity/energy. Or, five 100 watt light bulbs turned on for two hours would consume 1,000 Wh or 1 kWh.

Because most people have many light bulbs, along with televisions, computers, washers, dryers and other appliances in their homes, and therefore consume many thousands of watt hours (energy units) in a year, watt hours are often expressed in terms of kilowatt hours (kWh; one thousand watt hours), megawatt hours (MWh; one million watt hours), or gigawatt hours (GWh; one billion watt hours). Such measures are also used to measure how much electricity is actually produced by a power plant. On the other hand, in order to measure how much capacity for electricity generation a power plant or power source has, the amount of electricity available at any given moment is also measured, often in terms of kilowatts (kW), megawatts (MW), and gigawatts (GW).

To provide a frame of reference, in 2009, the total consumption of electricity in the United States was 3.7 trillion kWh, or 3.7 billion MWh. During 2009, the average household in the United States consumed about 10,900 kWh, 10.9 MWh, or, thought of in a different way, 1,244 watts on average at any given moment.[1]

However, it should be emphasized here that the consumption of energy (how much power is used over time) is not uniform. Households consume much more than 1,244 watts during peak hours of the day, for example during the middle of the day when it is hot and the air conditioning is turned on, as well as during certain times of the year. Alternatively, households consume less during the night when appliances and lights are turned off. Therefore, in order to ensure a stable, readily available supply of energy, the amount of electrical generation capacity that a household must have available at any one point in time to meet its needs at peak times is much higher than the average. In other words, if your home consumes on average 1,244 watts of power at any given moment, it will not be near enough to have only 1,244 watts of power connected to your home. You must have enough power available to meet your energy demands at their peak, which is likely much higher than the average amount.

RENEWABLE ENERGY RESOURCES

Renewable energy is derived from naturally replenished sources, such as sunshine, wind, or the movement of water. Renewables make up about 19% of electricity generation globally, with 16% coming from hydroelectric and 3% from so-called "new renewables," including energy derived from small hydro, modern biomass, wind, solar, geothermal and biofuels.[2]

While there are many renewable energy technologies, this report will focus on the major types, or the most commonly deployed and technologically advanced or commercially viable forms of renewable energy. Wind, solar, geothermal, biomass and hydroelectric energy all meet these criteria and represent the areas experiencing the most investment and rapid deployment worldwide.

In this section, each renewable resource technology will be described, followed by an explanation of the factors that must be considered in evaluating the real costs and benefits of using that resource in lieu of traditional, fossil fuel-based resources.

Wind Power

Electrical Generation

Wind turbines are windmills that connect to turbines and produce power when wind passes over the long blades of the windmill, rotating the turbine like the propeller of an airplane, thus producing electricity. Most commercial turbines are capable of generating 1.5 to 3.0 MW of power each. However, as with most renewable resources, reaching this capacity depends on the amount and quality of the wind where the turbine is installed. If winds are strong and sustained, more electricity is produced. If there is no wind or weak wind, no energy can be generated. Because of the high capital cost, strong wind resources are needed in order to drive down the cost per unit generated. If the wind resource is weak, then the cost per unit generated is higher. It is therefore important that wind farms are located in areas with regular, strong winds.

There are basically two major types of wind farms; those located on land and those located off-shore in the ocean or in lakes. Land-based wind farms are easier to hook into the electrical grid because of their proximity to it, with off-shore wind farms costing more to build and connect to the grid. On the other hand, off-shore wind farms have the potential to generate much more electricity because of the stronger and more frequent winds that occur over oceans and other large bodies of water, compared to land.

Environmental Impact

As with all energy resources, wind farms can have an adverse effect in the surrounding environment. First is the environmental or visual disruption that occurs where wind farms are located. In addition to requiring space to be built on, wind farms are often viewed as an eyesore ("view pollution") by those living within viewing distance of them, as well as a significant source of "noise pollution" due to the humming of the turbines and blades. Furthermore, the windmill blades pose a threat to birds that may migrate or fly through the area of the wind farm.

Current Market Viability

Wind power is one of the renewable resources that has seen some of the most financial investment, technological advances, and large scale deployment among renewable resources in recent years. The capital costs for installing wind turbines have been fluctuating over the last several years. While there is a general expectation of falling prices for technologies as time passes, this has not necessarily been the case for wind power. While some of this can be explained by shortages of access to some of the materials and parts needed to build wind farms, a larger part of it has to do with the fact that most manufacturing of wind turbines previously focused on smaller, less commercially suitable turbines, as opposed to the larger, multi-megawatt turbines favored by utilities today. However, this could change over time as manufacturing resources are reallocated toward building the larger turbines that are currently more in demand.

Also worth considering is the fact that China has made great efforts to ramp up its own domestic production of wind turbines through heavy subsidies and loans granted to turbine producers. China's aggressive expansion of wind power equipment production has led to trade disputes and even complaints brought by the United States before the World Trade Organization (WTO) that China is guilty of "dumping," or selling their products below cost in order to gain market share, in this case, in the United States. On the other hand, while this might be bad news for U.S. producers of wind power equipment, it is good news for consumers of wind energy; as prices for Chinese-made wind turbines have begun to fall. The result has been cheaper wind energy for utilities and their customers.[3]

Solar Power

Electrical Generation

Solar power is derived from the rays of the sun. Solar power works best as a source of electricity where the sun shines the most. It is therefore much less well-suited to areas where there is often cloud cover. As with wind, it is therefore an intermittent source of power.

However, there is somewhat of a nexus between the demand for electricity to power air conditioners in warmer climates and at hotter times of year and the periods when the sun is shining the most. Therefore, solar power can be an efficient and effective source of power for supplementing the electrical grids of areas that have high electricity demands for air conditioning during the summer, such as in the southern and western United States.

The two major ways in which solar power is used to produce electricity include generating electricity from photovoltaic cells and from concentrated solar power (CSP), otherwise known as solar thermal energy. Photovoltaic cells are the most familiar type of solar power, with arrays of darkly colored panels that convert light into electrical current. Photovoltaic cell arrays can be used on either a small or large scale. For example, individuals can install arrays on the roofs of their homes to provide their home with electricity, or much larger arrays can be installed on many acres of land to produce electricity for nearby communities or for contributing electricity to the nearby electrical grid.

CSP technology uses mirrors that rotate with the movement of the sun to direct light into a beam that focuses intensely on one receiving point, somewhat like a magnifying glass can be used to concentrate the rays of the sun on a specific spot. The heat generated by this is then used to heat liquid that produces the steam that rotates turbines to produce electricity. These liquids also retain heat well and can therefore be used to store heat to some extent for use when it is most needed to produce electricity. CSP power plants are most suitable for large-scale electricity generation due to the large capital investments and amount of space required to build them. CSP is also dependent on very specific meteorological and solar conditions to be effective. However, under the right conditions, CSP, when coupled with electrical storage capacity or fossil-fuel back-up, can serve as a reliable load following source of electrical generation, meaning that it can help meet base load demand and quickly ramp up production as the load increases during peak hours.

Environmental Impact

As with other power sources, solar power could potentially have an environmental impact if panels and mirrors are laid down and set up in environmentally sensitive areas. For example, several lawsuits were brought against the Energy Resources Conservation & Development Commission, an arm of the California Energy Commission, in 2011 because it was claimed they didn't accurately assess the large environmental impacts of some of the large solar plants being developed at the time.[4] Part of this impact is due to the large amounts of land solar plants require, for instance, the Calico Solar Project in southern California was constructed on more than 8,000 acres of land.[5]

Current Market Viability

Along with wind power, solar is one of the renewable resources that has seen some of the most financial investment, technological advances, and large-scale deployment among renewable resources in recent years. The U.S. government has also provided significant subsidies and tax incentives for the deployment of solar power equipment and for the development of new technologies. However, not all of these investments have been successful. In one notable instance, Solyndra, a California-based solar power technology firm that received $527 million in loan guarantees from the federal government, filed for bankruptcy, along with two other U.S.-based solar manufacturers, Evergreen Solar and SpectraWatt.[6]

In the midst of these bankruptcies, seven solar manufacturers in the U.S. have filed a trade case against the Chinese solar industry, pressuring the U.S. government to bring a trade complaint against China in the WTO. The companies claim that less expensive Chinese competitors have unfairly gained large market share in the U.S. because they received large subsidies and loans from the Chinese government, helping lower their production costs for U.S. market-bound products. Under WTO rules, subsidies and cheap loans from governments to companies are permissible, as long as the companies primarily sell their products domestically. Most Chinese-made solar panels are destined for the U.S. and European markets. These events have resulted in Chinese firms occupying a dominant role in the U.S. and global solar panel markets.[7]

Despite the claims of U.S. solar power firms concerning the expansion of Chinese firms into the U.S. solar power market, some experts have noted that the U.S.-based solar firms that have gone bankrupt, Solyndra in particular, were focused on producing more advanced solar technologies that are inherently more costly and that this could also have been a contributing factor to the companies' demise. Chinese firms, on the other hand, produced slightly less-advanced equipment that was ostensibly cheaper to manufacture.[8]

The net result of all these events, however, has been a positive one for individuals and companies investing in solar power equipment; prices are falling and can be expected to continue to do so. According to Bloomberg New Energy Finance, the 2010 cost of solar panels was $1.80 per watt, with the cost declining to $1.50 by the end of 2011.[9] When subsidies are included, the price of utility-scale solar power is approaching that of natural gas, but is still higher than coal. On the other hand, though, residential solar panel costs (as opposed to large, utility-scale installations), while falling by 17% between 2009 and 2010, are still relatively high, at about $6.20 per watt installed because of the costs of residential installations, wiring, permitting, etc.[10]

Geothermal Power

Electrical Generation

Geothermal energy harnesses the heat generated by the earth's core to generate electricity or to heat or cool buildings. The former is done in one of three ways: dry steam, flash and binary. With the dry steam method, steam from holes drilled into the earth is channeled into turbines that turn and produce electricity. The flash method takes boiling hot water out of the ground and uses the steam from it to drive turbines. The binary technique uses hot primary fluid, such as butane or pentane, to heat a secondary fluid that, in turn, produces steam to drive turbines. As with other renewable resources, in order to work as an efficient and reliable source of electricity, geothermal power plants need to be located in areas with favorable natural conditions, in this case, where hotter portions of the earth's crust are closer to the surface, within drilling distance. Because of the high capital costs of building geothermal plants, this type of geothermal power is used for large-scale electricity generation.

Direct Use

Geothermal energy can also be used to help heat or cool buildings, reducing their reliance on air conditioning and heating systems that use external sources of energy, such as electricity or natural gas. Geothermal, or ground heat pumps, take advantage of the difference between the heat of the ground, just below the surface, and the air above the ground. The heat pumps are filled with liquid and run from inside the building down under the ground below the building. When the temperature of the air in the building is cooler than the temperature under the ground, such as during winter, the liquid in the pumps above ground, which is also cooler, moves down under ground, and the warmer liquid underground rises and replaces the cooler liquid inside the building, giving off heat inside the building. The reverse happens when the air in the building is warmer than the air underground, such as during the summer, and the system cools the air in the building. This type of geothermal energy is scalable for either individual buildings or for multiple buildings. Geothermal heat pumps, once installed, are quite reliable and last for many years. They can also significantly reduce the costs of heating (by 30-70%) and cooling (by 20-50%) compared to traditional systems. Both forms of geothermal power—electrical generation plants and heat pumps—also provide stable, constant supplies of energy without much interruption, and can be considered as base load generation, in contrast to some other renewables, which are more intermittent.

Environmental Impact

The environmental costs imposed by the building and operating of geothermal plants consist of the damage from drilling and the underground gases, such as sulfur, released along with geothermal heat.

Current Market Viability

Recently, there has been significant private and public investment in developing geothermal resources. Nevada Geothermal Power, for example, is the recipient of a $79 million loan guarantee and $66 million in grants, both from the federal government. However, it has struggled with debt and its viability is in question. A high debt load and lower output than initially projected have contributed to these circumstances, although the company's executives remain optimistic about their long-term prospects.[11]

Utah is one of the few states with operating geothermal power plants and has been one of the locations for geothermal development. For example, Raser Technologies has built a 10 MW geothermal plant near Beaver. However, Raser Technologies has come under financial pressure, with less net output than anticipated from the plant due to, among other things, the plant itself consuming more of the energy it produces than anticipated. Also, as the company claims, the use of smaller turbines has not delivered on the efficiencies promised by their manufacturer. Despite filing for bankruptcy, the company has continued to operate, selling the electricity it generates to California.[12]

On the other hand, the Blundell geothermal power station, located near Milford, is an example of a successfully operating geothermal plant in Utah. It has been in operation since 1984 and has a total capacity of 37 MW.[13]

Biomass Power

Electrical Generation and Direct Use

Biomass power is energy that is derived from biological material, including landfill and animal waste and gas, as well as plants and other organisms that contain energy derived from the sun through the process of photosynthesis. When waste, plants and other biological material are burned or converted to energy through chemical processes, the heat or energy released can be used to produce heat directly or to rotate turbines and produce electricity. The burning of wood for either heat or electricity is one example of biomass energy.

There are two approaches to using biomass to produce energy. One is to grow plants dedicated for energy use. The other is to use waste and the plant materials that are the by-products of other processes, such as in the industrial manufacturing of paper, which uses wood and produces several wood by-products as waste. That waste can than be used to generate energy.

Biomass is considered a renewable energy resource because vegetation and other plant matter continues to grow indefinitely, if given the land and resources to do so, and waste is produced indefinitely by living organisms. However, these processes are only sustainable if the amount of biomass used for generating energy is less than or equal to the amount of biomass that is produced.

Environmental Impact
Biomass imposes environmental costs through the use of land for growing biomass material, as well as the harvesting of that material. Furthermore, the burning of biomass has the potential to release gases and particles into the air, depending on the material used.

Current Market Viability
Biomass is usable as an energy source on either a small scale, such as burning wood to heat a home, or on a large scale, with vegetation being specifically grown and harvested to produce energy. Unlike other renewable energy technologies, biomass electricity generators do not need to be located close to where the biomass is grown or collected. Whether it is advantageous to do so depends on the costs of transporting the biomass fuel compared to the costs associated with transmitting electricity long distances to hook into the electrical grid or to power homes. Biomass is also not subject to the same problems of intermittent availability that, for example, wind and solar power are. Utah currently has some limited biomass electrical production, utilizing methane derived from municipal solid waste (MSW) from the Salt Lake City and Davis Country landfills. Utah produces a total of 9 MW in this manner.[14]

Hydroelectric Power

Electrical Generation and Direct Use
Hydroelectric power is the most common and widely deployed type of renewable electricity power source. While there are many forms of hydroelectric power generation, what they all have in common is harnessing the power of moving water, which usually drives turbines that rotate and generate electricity. Dams are the most common form of hydro power. By building large concrete walls in the paths of rivers and near lakes, and by allowing some of that water to pass through the turbines in a dam, electricity is generated.

Other ways of generating hydroelectric power include harnessing the movement of water in rivers, as well as waves and tides in the ocean and large bodies of water through placing turbines that rotate with the flow of the water. Yet another form of hydroelectric power takes advantage of the movement of water from higher ground to lower ground. This can be done is by placing turbines in the path of channels dug to connect two bodies of water, one higher and one lower, with water flowing downhill.

Environmental Impact
Hydroelectric power, in the form of dams, also has the potential of harming the environment in the vicinity of the dam, both upstream and down through affecting fish, as well as river sediments and chemistry. Nonetheless, hydroelectric dams have a very long life of operation, with some plants in service after 50 to 100 years. Furthermore, dams require little maintenance and few on-site personnel to operate them once the dams are constructed. There can also be an environmental impact if a dam is decommissioned, such as loss of wetlands and water habitats upstream, and damaging water and plant life downstream when large amounts of sediment that were once held back by the dam are washed down-river. For example, when the Condit Dam on the White Salmon River in Washington was decommissioned in October of 2011, the draining of the reservoir caused a large sediment plume to be released downstream.[15]

Current Market Viability
As with all types of renewable resources, the cost and availability of hydroelectric power are related to where the resource is located relative to the electrical grid or area to be served. Off-shore hydroelectric power, such as turbines that harness the power of waves and tides are thus more expensive and harder to connect to the electrical grid than sources located on land or close to population centers. Compared to wind and solar power, hydroelectric is a fairly stable and reliable power source, but not quite as reliable and constant as geothermal or biomass power.

The future of large hydro-electric generation projects is in question. Most suitable sources of large hydro are already tapped and both potential and existing facilities face political opposition from groups concerned about their environmental impact. "Small hydro," or projects that do not involve the building of large dams, such as smaller turbines that harness ocean tides and currents and river flows, seem to have a more promising future due to less opposition to their construction compared to dams, which now face strong political resistance, with some groups even demanding that certain dams be removed permanently.

Base Load, Peak Capacity and Intermittence

In understanding the role of renewable energy in overall electricity generation, it is important to briefly explain the concepts of base load, peak capacity and intermittent power sources. Base load is the amount of electricity that must be generated at any given time in order to meet the minimum amount of electricity demanded in a given area. Base load must always be available, otherwise black outs and losses of power will occur. Therefore, energy sources that are used for providing base load must be on tap continuously. Peak capacity is the maximum amount of electricity that must be available at any given time in order to meet the demand above and beyond the base load generation requirements. Energy sources that are used to provide peak capacity therefore do not need to be continuously available. However, such energy sources must be available during periods of peak electricity demand, such as during the warmest hours of the day for air conditioning (e.g. the afternoon) or the coldest times of year for heat.

Intermittent power sources are sources that are variable in the times and amounts of power that they can provide. In other words, they are not continuously available as a source of base load power, or even peak power, depending on when peak demand occurs. Power plants that use resources such as coal, natural gas, nuclear, hydro, geothermal and biomass are good for meeting base load requirements because their fuel is available more or less continuously. Wind and solar power, on the other hand, are intermittent sources of power, due to the variable availability of wind and sun, depending on weather and seasonal conditions. This means that wind and solar power are not suitable for meeting base load demands. Rather, they are better suited as resources that complement the existing baseload resource mix, helping to meet peak demand. Alternatively, they can supplement a resource such as natural gas that can quickly increase electrical generation in response to a dip in wind or solar production because of weather or other conditions.

Energy Storage

An important complement to renewable energy technologies are energy storage technologies, including batteries. Because the sun does not always shine and the wind does not always blow on demand, or when they are needed most, energy storage technologies provide the opportunity of storing energy produced when it is not needed for use later when it is. Currently, energy storage is mostly used to help meet peak electricity demand, capturing renewable energy generated during off-peak hours to supplement baseload when energy demands are at their highest. However, if energy storage technologies are developed to the point where they could hold more energy more efficiently, and renewable energy resources are developed to the point where they could produce more energy, renewables could have the potential to contribute to baseload demand as well, through energy storage. In this way, such technologies help electricity generation to meet electricity demand. In so doing, renewable energy resources can make a larger and more valuable contribution to the electrical grid. While there are numerous energy storage technologies, only those that are most appropriate for or most applicable to renewable energy will be discussed here.

Rechargeable batteries are probably the most familiar form of energy storage and rely on chemical processes to produce or receive and store electricity. Industrial-scale batteries are in use today in electrical grids. However, batteries are limited in their capacity, and are expensive and high-maintenance. Nonetheless, there is significant research currently ongoing into the potential for next-generation batteries that could make a more significant contribution to the electrical grid.

Electro-mechanical batteries are not batteries in the traditional sense of using chemical reactions to produce electricity. Rather, they rely on mechanical methods, using flywheels to effectively store kinetic energy for use when it is needed. Compressed air is another energy storage technique that forces air into a limited space when energy demands are low and then releases that air through turbines to help generate electricity during peak hours. The production of hydrogen, which is compressed or liquefied for later conversion to electricity is also a way of storing energy that is in use today. Electricity can also be stored in "superconducting magnetic fields," or coils, in what is called "superconducting magnetic energy storage" (SMES).

Another method for storing energy is through using the energy generated during non-peak times when demand and cost are less (e.g. at night when lights and air conditioners consume less energy) to pump water to higher-elevation pools or reservoirs. When demand and costs are higher, the water is then released to run downhill through turbines, generating electricity and increasing peak generation capacity. Similarly, energy can also be stored through using electricity produced during off-peak hours to cool water and produce ice. Later, when demand is higher, the ice can be melted to give off steam, which can drive turbines.

Finally, molten salts or "thermal batteries" can be used as a way of storing energy in the form of heat, to be released later to create steam, driving turbines. Molten salts are used in conjunction with CSP solar plants, where the heat produced by the plant is stored in the salts. Molten salts have proven particularly efficient at heat storage.

As is evident, there are quite a number of energy storage technologies available. The reason they have not been deployed more widely is because of limitations in their storage capacity, efficiency losses, cost and maintenance. However, the technologies in this field are rapidly advancing, with increases in efficiencies and capacities, and decreases in costs.

Figure 1: State Electricity Prices, Capacity, Generation and Sales

	Average Retail Price (cents/kWh)	Net Summer Capacity (MW)	Net Generation (MWh)	Total Retail Sales (MWh)
U.S.	9.82	1,025,400	3,950,330,926	3,596,864,866
Alabama	8.83	31,389	143,255,556	82,844,602
Alaska	15.09	2,012	6,702,159	6,269,927
Arizona	9.56	26,335	111,971,250	73,432,929
Arkansas	7.57	15,275	57,457,739	43,173,104
California	13.24	65,948	204,776,132	259,583,623
Colorado	8.31	13,038	50,565,952	51,035,906
Connecticut	18.06	8,028	31,206,222	29,715,764
Delaware	12.14	3,362	4,841,563	11,257,778
District of Columbia	12.97	790	35,499	12,198,825
Florida	11.49	59,073	217,952,308	224,750,322
Georgia	8.81	36,549	128,698,376	130,765,505
Hawaii	21.21	2,565	11,010,533	10,126,185
Idaho	6.51	3,758	13,100,152	22,753,779
Illinois	9.08	44,033	193,864,357	136,688,466
Indiana	7.62	27,949	116,670,280	99,311,813
Iowa	7.37	14,579	51,860,063	43,641,195
Kansas	7.98	12,529	46,677,308	38,243,344
Kentucky	6.52	20,160	90,630,427	88,809,175
Louisiana	7.06	25,987	90,993,676	78,669,582
Maine	13.09	4,344	16,349,849	11,282,967
Maryland	13.08	12,482	43,774,832	62,589,143
Massachusetts	15.45	13,699	38,966,651	54,359,198
Michigan	9.4	30,308	101,202,605	98,121,014
Minnesota	8.14	14,626	52,491,849	64,004,463
Mississippi	8.85	15,820	48,701,484	46,049,154
Missouri	7.35	20,829	88,354,272	79,686,603
Montana	7.57	5,779	26,712,735	14,326,159
Nebraska	7.21	7,768	34,001,892	28,452,194
Nevada	10.36	11,396	37,705,133	34,283,654
New Hampshire	15.13	4,165	20,164,122	10,698,493
New Jersey	14.52	18,499	61,811,239	75,779,853
New Mexico	8.09	7,993	39,674,339	21,647,136
New York	15.52	39,671	133,150,550	140,034,397
North Carolina	8.48	27,618	118,407,403	127,657,979
North Dakota	6.63	5,963	34,196,467	12,648,580
Ohio	9.01	33,539	136,090,225	146,299,793
Oklahoma	6.94	20,849	75,066,809	54,536,799
Oregon	7.48	13,985	56,690,856	47,566,897
Pennsylvania	9.6	45,611	219,496,144	143,747,438
Rhode Island	14.23	1,780	7,696,824	7,617,629
South Carolina	8.42	23,971	100,125,486	76,417,479
South Dakota	7.39	3,362	8,196,531	11,010,118
Tennessee	8.69	20,852	79,716,889	94,650,259
Texas	9.86	103,037	397,167,910	345,295,561
Utah	**6.77**	**7,418**	**43,542,946**	**27,586,700**
Vermont	12.75	1,126	7,282,348	5,496,513
Virginia	8.93	23,788	70,082,066	108,462,463
Washington	6.6	30,095	104,470,133	90,164,701
West Virginia	6.65	16,360	70,782,514	30,271,329
Wisconsin	9.38	17,744	59,959,060	66,286,439
Wyoming	6.08	7,566	46,029,212	16,561,937

Source: Energy Information Administration's Annual Energy Outlook 2011.

Figure 2: State Electricity Generation and Emissions

	Primary Fuel Source	Total Net Summer Capacity (MW)	Rank	Net Generation (MWh)	Rank	Sulfur Dioxide Emissions (1,000 Metric Tons)	Rank	Nitrogen Oxide Emissions (1,000 Metric Tons)	Rank	Carbon Dioxide Emissions (1,000 Metric Tons)	Rank
U.S.	Coal	1,025,400		3,950,330,926		5970		2395		2,269,508	
Alabama	Coal	31,389	9	143,255,556	6	285	7	53	19	69,239	11
Alaska	Gas	2,012	48	6,702,159	49	4	46	17	38	4,240	45
Arizona	Coal	26,335	14	111,971,250	12	33	33	62	15	53,524	15
Arkansas	Coal	15,275	26	57,457,739	25	75	24	37	29	30,427	31
California	Gas	65,948	2	204,776,132	4	3	47	83	7	59,428	14
Colorado	Coal	13,038	31	50,565,952	29	43	30	54	18	38,989	22
Connecticut	Nuclear	8,028	35	31,206,222	40	2	48	6	45	8,046	42
Delaware	Coal	3,362	46	4,841,563	50	16	39	6	46	4,143	46
District of Columbia	Petroleum	790	51	35,499	51	*	49	*	51	36	50
Florida	Gas	59,073	3	217,952,308	3	219	11	116	3	114,854	4
Georgia	Coal	36,549	7	128,698,376	9	295	5	74	10	77,022	8
Hawaii	Petroleum	2,565	47	11,010,533	45	22	37	22	35	8,661	41
Idaho	Hydroelectric	3,758	44	13,100,152	44	5	45	2	49	1,024	49
Illinois	Nuclear	44,033	5	193,864,357	5	237	8	78	8	98,975	6
Indiana	Coal	27,949	12	116,670,280	11	384	4	111	4	111,113	5
Iowa	Coal	14,579	28	51,860,063	28	92	21	45	24	42,978	21
Kansas	Coal	12,529	32	46,677,308	31	47	28	46	23	36,207	26
Kentucky	Coal	20,160	21	90,630,427	17	232	10	74	9	86,155	7
Louisiana	Gas	25,987	15	90,993,676	16	98	20	69	12	53,226	16
Maine	Gas	4,344	42	16,349,849	43	33	32	12	43	4,714	44
Maryland	Coal	12,482	33	43,774,832	33	197	12	23	34	25,659	32
Massachusetts	Gas	13,699	30	38,966,651	36	33	31	17	39	19,683	35
Michigan	Coal	30,308	10	101,202,605	14	288	6	91	6	73,589	10
Minnesota	Coal	14,626	27	52,491,849	27	65	26	49	21	33,689	28
Mississippi	Gas	15,820	25	48,701,484	30	45	29	27	32	23,481	34
Missouri	Coal	20,829	20	88,354,272	18	236	9	52	20	74,716	9
Montana	Coal	5,779	41	26,712,735	41	23	36	21	36	17,548	37
Nebraska	Coal	7,768	37	34,001,892	39	70	25	44	26	23,899	33
Nevada	Gas	11,396	34	37,705,133	37	7	44	17	39	18,295	36
New Hampshire	Nuclear	4,165	43	20,164,122	42	31	34	5	47	5,507	43
New Jersey	Nuclear	18,499	22	61,811,239	23	12	42	14	41	16,086	38
New Mexico	Coal	7,993	36	39,674,339	35	18	38	61	16	33,502	29
New York	Nuclear	39,671	6	133,150,550	8	59	27	44	27	38,130	23
North Carolina	Coal	27,618	13	118,407,403	10	126	15	44	25	64,845	13
North Dakota	Coal	5,963	40	34,196,467	38	121	17	59	17	32,608	30
Ohio	Coal	33,539	8	136,090,225	7	624	1	110	5	115,066	3
Oklahoma	Gas	20,849	19	75,066,809	20	92	22	73	11	51,986	17
Oregon	Hydroelectric	13,985	29	56,690,856	26	12	41	13	42	9,406	40
Pennsylvania	Coal	45,611	4	219,496,144	2	585	2	120	2	116,621	2
Rhode Island	Gas	1,780	49	7,696,824	47	*	50	3	48	3,181	48
South Carolina	Nuclear	23,971	16	100,125,486	15	105	19	24	33	38,121	24
South Dakota	Hydroelectric	3,362	45	8,196,531	46	11	43	11	44	3,511	47
Tennessee	Coal	20,852	18	79,716,889	19	125	16	30	31	43,458	20
Texas	Gas	103,037	1	397,167,910	1	419	3	199	1	242,864	1
Utah	**Coal**	**7,418**	**39**	**43,542,946**	**34**	**30**	**35**	**68**	**13**	**36,518**	**25**
Vermont	Nuclear	1,126	50	7,282,348	48	*	51	1	50	7	51
Virginia	Nuclear	23,788	17	70,082,066	22	118	18	39	28	36,161	27
Washington	Hydroelectric	30,095	11	104,470,133	13	13	40	18	37	13,526	39
West Virginia	Coal	16,360	24	70,782,514	21	167	13	35	30	65,928	12
Wisconsin	Coal	17,744	23	59,959,060	24	139	14	49	22	44,233	19
Wyoming	Coal	7,566	38	46,029,212	32	76	23	66	14	44,684	18

Note: * = Value is less than half of the smallest unit of measure (e.g., for values with no decimals, values under 0.5 are shown as *).

Source: Energy Information Administration's Annual Energy Outlook 2011.

ENERGY MARKETS

In order to get a sense of the status of energy markets generally, as well as renewable energy markets specifically, both in the United States and in Utah, the following information from the Energy Information Administration's (EIA) Annual Energy Outlook 2011 will be presented and discussed.

The U.S. Energy Market

Figure 1 displays the average prices paid by consumers for electricity in different states, the amount of peak capacity states have, how many MWh they generate, and how much energy they consume. It is notable that Utah has some of the lowest energy prices in the country. This is one of the reasons Utah is attractive for businesses, especially electricity-intensive operations, such as computer server farms and manufacturing. Because renewable energy is generally more expensive than Utah's current energy prices, an increase in renewable energy sources for generating electricity could increase these costs for Utah.

On the other hand, higher prices in places like California present the opportunity to export electricity produced by renewables in Utah. This is especially true when, as with California, the state buying the electricity has mandatory renewable portfolio standards (RPS), or regulations requiring that a certain amount of electricity be produced from renewable resources. On a technical level, until recently, "exporting electricity" has not necessarily meant building transmission lines from Utah renewable plants to California homes. Rather, the electricity generated by renewables is added to the western electricity grid and is then transported throughout the western states to specific delivery points. The additional cost of renewable energy (compared to the rates charged for natural gas and coal power) is charged according to terms agreed to with the utility, municipality or other entity buying the renewable energy.

The "Net Summer Capacity" and "Net Generation" are measures of how much electricity a state can produce at any given moment and over time, respectively. These figures give a sense of the relative generation capacities of states, with Utah producing relatively little electricity, a fact that is explained by Utah's smaller population

Figure 3: State Renewable Capacity and Generation

	Net Summer Capacity (MW)	Rank	Net Generation (1,000 MWh)	Rank
U.S.	127,070		417,724	
Alabama	3,863	6	15,585	6
Alaska	422	41	1,337	42
Arizona	2,826	10	6,630	14
Arkansas	1,659	21	5,778	18
California	16,295	2	53,428	2
Colorado	1,931	17	5,132	19
Connecticut	287	45	1,268	44
Delaware	7	50	126	50
District of Columbia	n/a	n/a	n/a	n/a
Florida	1,093	29	4,549	21
Georgia	2,648	12	6,085	16
Hawaii	341	44	817	48
Idaho	2,909	9	11,302	7
Illinois	1,777	19	3,666	29
Indiana	1,141	28	2,209	38
Iowa	3,511	7	8,560	10
Kansas	1,014	30	2,876	33
Kentucky	893	31	3,681	28
Louisiana	579	38	3,600	30
Maine	1,606	22	8,150	11
Maryland	727	34	2,440	34
Massachusetts	564	39	2,430	35
Michigan	792	33	3,995	25
Minnesota	2,192	14	7,546	12
Mississippi	229	46	1,424	41
Missouri	880	32	2,391	36
Montana	3,078	8	10,422	9
Nebraska	393	43	883	47
Nevada	1,446	24	4,269	23
New Hampshire	691	35	2,878	32
New Jersey	221	47	992	46
New Mexico	686	36	1,851	40
New York	6,013	5	32,082	4
North Carolina	2,294	13	7,065	13
North Dakota	1,720	20	4,484	22
Ohio	216	48	1,161	45
Oklahoma	2,057	15	6,482	15
Oregon	10,359	3	37,306	3
Pennsylvania	1,971	16	6,035	17
Rhode Island	26	49	149	49
South Carolina	1,580	23	4,080	24
South Dakota	1,914	18	4,859	20
Tennessee	2,817	11	11,162	8
Texas	10,354	4	22,133	5
Utah	**521**	**40**	**1,322**	**43**
Vermont	406	42	1,915	39
Virginia	1,403	26	3,896	26
Washington	23,504	1	77,977	1
West Virginia	594	37	2,388	37
Wisconsin	1,212	27	3,734	27
Wyoming	1,408	25	3,193	31

Source: Energy Information Administration's Annual Energy Outlook 2011.

compared to states that must serve more people. "Total Retail Sales" is the amount of MWh that a state has consumed. By comparing the amount of MWh generated with the amount consumed, it is possible to see which states export excess electricity generation. Utah, for example, produces 16 million MWh more electricity than it consumes.

Utah, like a majority of states, relies on coal as its primary source of electrical power, as seen in Figure 2. In terms of sulfur dioxide emissions, Utah produces 30,000 metric tons annually, ranking 35th highest in the nation. Utah's nitrogen oxide emissions are higher, at 68,000 tons, ranking 13th highest. Finally, Utah emits 36.5 million tons of carbon dioxide per year, ranking 25th highest in the country.[16] It should be noted here, however, that Utah power companies have recently made significant investments in technologies that reduce emissions from existing coal-fired plants that are not reflected in the above numbers. Increased reliance on renewable energy would further reduce these emissions for any given level of power output.

Figure 3 displays the amount of electricity that states generate from renewable resources. This is given in terms of both total capacity (MW) and the actual, generated amount (MWh). Utah has the installed capacity to generate 521 MW, which ranks 40th in the nation. The amount of electricity that Utah actually generated in 2010 was 1.3 million MWh, ranking 43rd among states.[17]

Utah's Energy Market

The electricity produced in Utah is heavily derived from coal, with some smaller contributions from natural gas-fired and hydroelectric plants. This is in large part due to the fact that Utah has abundant and cheap supplies of coal within the state. However, this is changing with the introduction of new natural gas-fired plants and the impending retirement of some coal facilities. Much of the renewable energy that Utah does produce is exported.

In order for energy to be exported, transmission lines must connect the exporting market with the importing one. A development that could facilitate Utah's continued role as an electricity exporter, including exporting renewable energy, is the potential construction of a 1,300-mile, high-capacity electrical transmission line running from Wyoming to California that would allow up to 12,000 MW of electricity to flow from lower-demand states like Utah to higher-demand ones, like California. Four western governors have agreed to pursue this possibility, with one study confirming the feasibility of the project and a second currently being conducted.[18] The driving factor behind the construction of the transmission line is the availability of good wind resources in Wyoming that can be harnessed and exported as energy to California, which has a demand for renewable energy. However, Wyoming and Utah customers contend that the construction of such a transmission line should not be paid for by them, but rather by the California utilities that will be importing the energy.

With the capacity to generate 521 MW of electricity in the state, renewable resources make up 7% of Utah's generation capacity, with 3.6% coming from "new" renewables.[19] Much of this capacity comes from traditional hydroelectric sources, such as dams. A close second is Utah's wind power capacity. Although Utah's two geothermal plants contribute only half of one percent of Utah's total electrical generation

Figure 4: 2009 Summary Renewable Electric Power Industry Statistics (Utah)

Capacity (MW)	Value	Percent of State Total
Total Net Summer Electricity Capacity	7,418	100.0%
Total Net Summer Renewable Capacity	521	7.0%
Geothermal	34	0.5%
Hydro Conventional	256	3.5%
Solar	n/a	n/a
Wind	222	3.0%
Wood/Wood Waste	n/a	n/a
MSW/Landfill Gas	9	0.1%
Other Biomass	n/a	n/a

Generation (1000 MWh)	Value	Percent of State Total
Total Electricity Net Generation	43,543	100.0%
Total Renewable Net Generation	1,322	3.0%
Geothermal	279	0.6%
Hydro Conventional	835	1.9%
Solar	n/a	n/a
Wind	160	0.4%
Wood/Wood Waste	n/a	n/a
MSW Biogenic/Landfill Gas	48	0.1%

Notes: Hydro Conventional does not include pumped storage. Solar includes solar thermal and photovoltaic. MSW = Municipal Solid Waste. Other Biomass includes agricultural byproducts/crops, sludge waste and other biomass solids, liquids and gases. MSW Biogenic includes paper and paper board, wood, food, leather, textiles and yard trimmings. Totals may not equal sum of components due to independent rounding.

Sources: Capacity: U.S. Energy Information Administration, Form EIA-860, "Annual Electric Generator Report." Generation: U.S. Energy Information Administration, Form EIA-923, "Power Plant Operations Report."

Figure 5: Potential Renewable Electricity Generation in Utah

Resource	Location	Electricity Generation Potential (MWh/yr)
Wind	Northeast, Central	23,000,000
Solar	South, East	69,000,000
Geothermal	Central, Northwest	9,000,000
Biomass	Northwest	1,000,000

Source: Renewable Energy Atlas of the West: A Guide to the Region's Resource Potential.

capacity, Utah is one of the few states to have any geothermal power capacity at all. However, as has been noted earlier, the actual generation from renewables, as opposed to the generation capacity, depends on how reliably, for example, the wind blows and the sun shines.

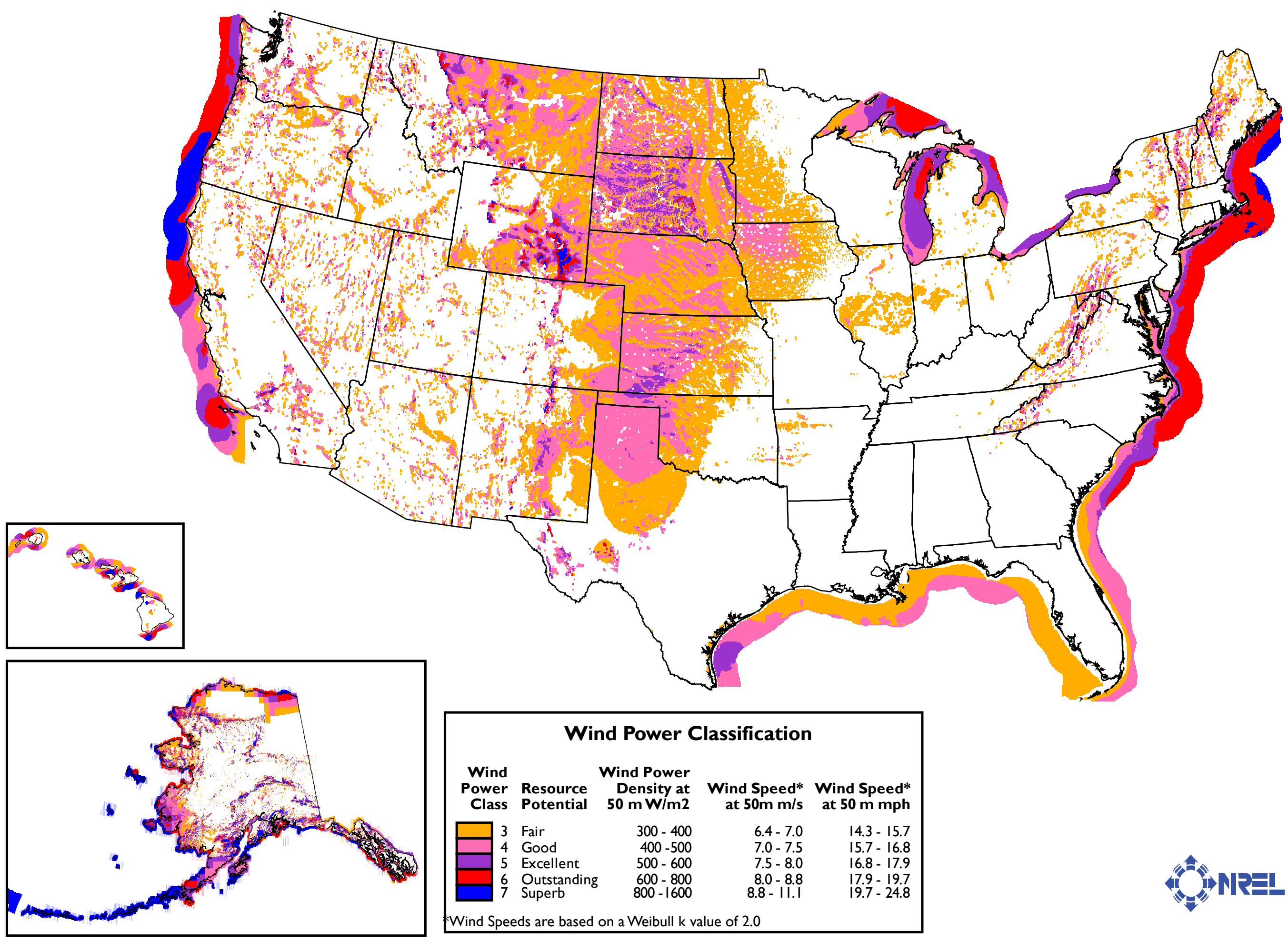
While Utah is currently taking advantage of some of its renewable resource potential, there is much more available for development. Figure 5 illustrates how much electricity could technically be produced were Utah to tap all of its wind, solar, geothermal and biomass resources. From this figure, it is evident that Utah has an abundance of solar, wind and, to a significant extent, geothermal resources. However, there are several caveats to these estimates. First, they are broad estimates. Second, they are "technically feasible" estimates, which assume that all the available land would be available for developing renewable resources, without taking into account the economic, political and other concerns that might arise from building, say, a wind farm in a certain place. While it is technically feasible to develop these renewable energy resources, it is not necessarily economically feasible to do so because of the costs of extending transmission lines long distances to hook some renewable resources into the electrical grid, where the power they generate can then be distributed and used. A final issue that pertains to developing renewable resources is the ability to secure access to the lands with the best resource potential when, in many cases, such lands are designated wilderness areas or are located in national and state parks.

ENERGY COSTS COMPARED

Explaining Costs

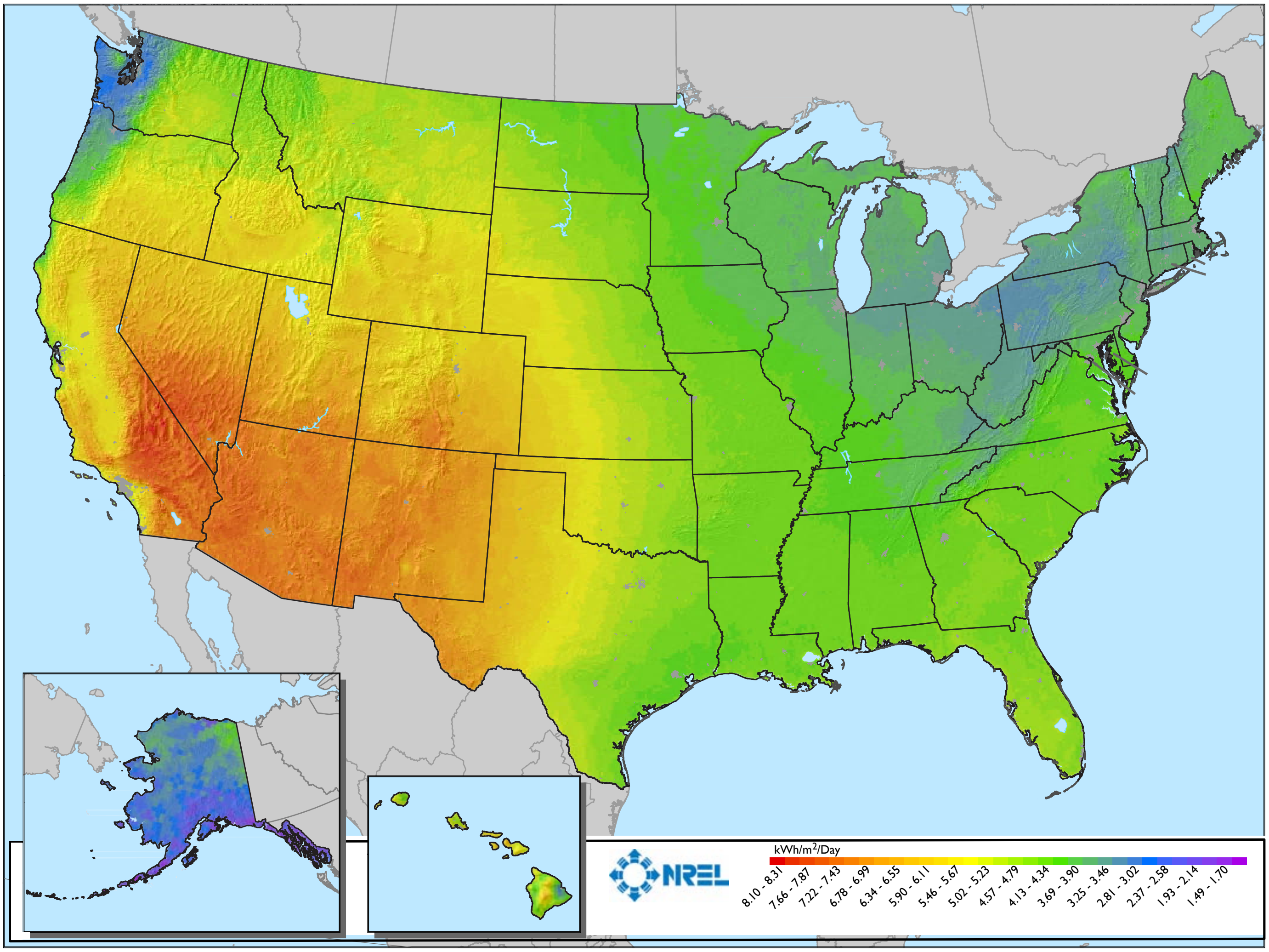
In order to compare the costs of renewable energy resources with traditional, fossil-fuel resources directly and quantitatively, this report will refer to the Energy Information Administration's (EIA) National Energy Modeling System (NEMS), which is used to calculate Levelized Energy Costs (LECs) for different renewable and traditional energy resources. The EIA is a statistical and analytical agency in the U.S. Department of Energy charged with collecting, analyzing and

Figure 6: United States - Wind Resource Map



Source: U.S. Department of Energy, National Renewable Energy Laboratory (NREL), May 6, 2009.

Figure 7: Concentrating Solar Power: U.S. Direct Normal Solar Resource, kWh Per Square Meter Per Day



Note: Annual average direct normal solar resource data is shown. The data for Hawaii and the 48 contiguous states is a 10 km, satellite modeled dataset (SUNY/ NREL, 2007) representing data from 1998-2005. The data for Alasks is a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).

Source: NREL, January 23, 2008.

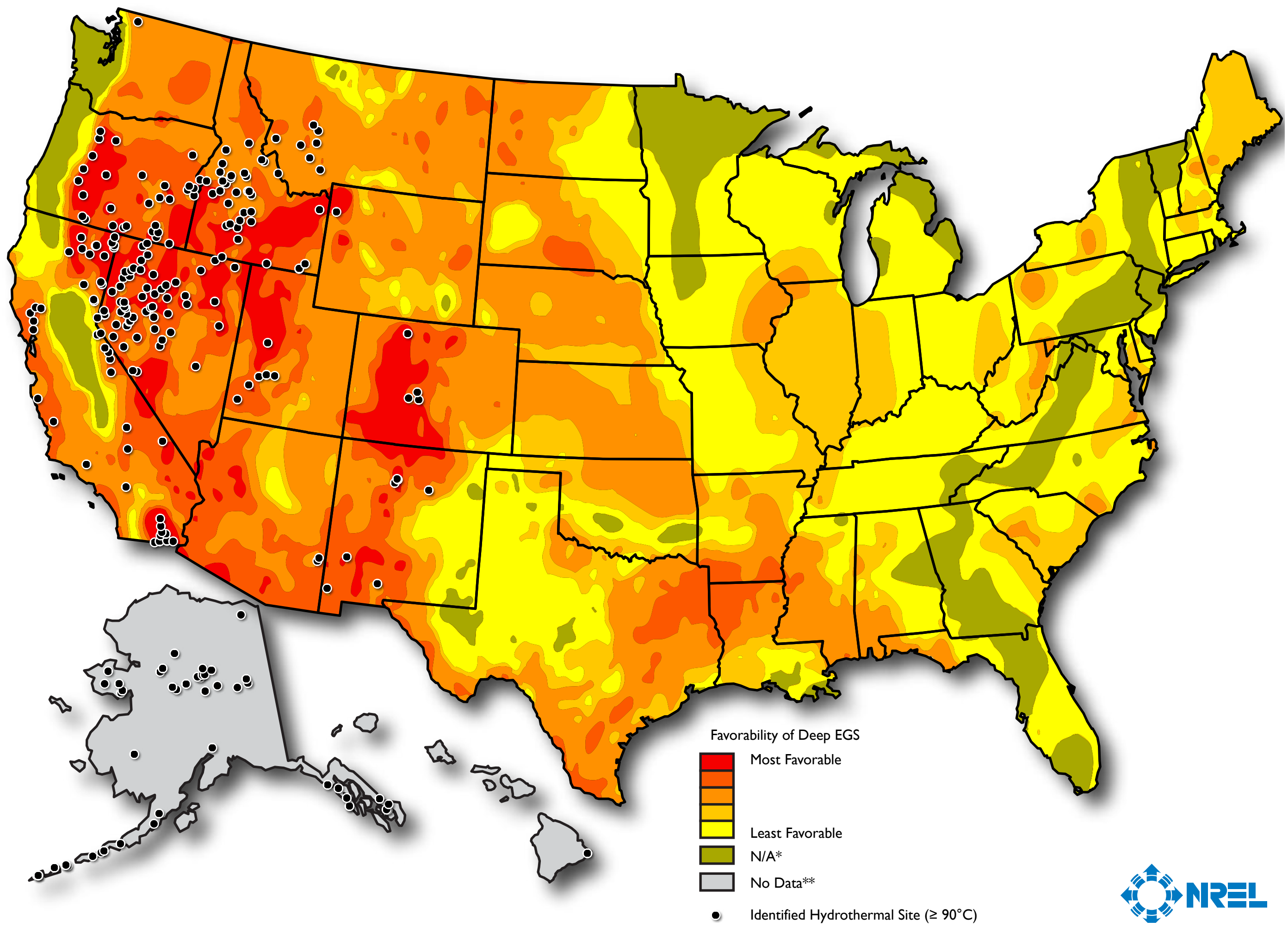
disseminating energy information of all types. NEMS is an analytical model used to evaluate a range of energy data and project scenarios. LECs are a way of calculating and comparing the costs of different energy resources. They incorporate current and projected economic data and serve as a useful tool for making direct comparisons between energy resources. While there are other measures of cost (such as dollars per kilowatt/megawatt), LECs currently are the comparison tool that offers the most comprehensive account of the various costs and benefits of building new energy plants available. LECs take a comprehensive view of the economic factors that play a role in how much a new energy plant will cost, relative to other types of plants. Before turning to the LEC data, however, it is important to explain what the LECs include and what they don't, what they can reveal and what they can't.[20]

In short, what LECs include are the capital costs of new generation capacity for different energy resources (i.e. if you were to build a plant today), fuel costs, fixed and variable operations and maintenance costs (O&M), financing costs, and an assumed utilization rate (how much a given power plant will be able to be used) for each different resource. LECs represent the total cost of building and operating a plant over an assumed financial and operational life cycle, averaged over the years of operation and expressed in inflation-adjusted dollars. LECs are meant to be used as cost-comparison tools for utility-scale energy technologies.[21]

It is important to note here that LECs are inherently uncertain. For example, for energy technologies that require fuel, such as coal or natural gas plants, fuel-cost variations can affect their respective LECs. There are also significant regional variations in LECs for different energy resources, and all costs, including the costs of technology, can vary across time. The data that these LECs were calculated with are the most recent available and come from 2009. The LECs calculated by the EIA are intended as a one-time project and will not be updated annually. The LECs here are used to project the costs for projects that would come online for service in 2016 and have a project life of 30 years.[22]

It is also important to note that these LECs do not incorporate government incentives or policies that would affect the calculations of LECs for any specific, given plant. Such incentives and policies are difficult to include in the calculations because of their local and

Figure 8: Geothermal Resource of the United States: Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)



Notes:
Map does not include shallow EGS resources located near hydrothermal sites or USGS assessment of undiscovered hydrothermal resources.
Source data for deep EGS includes temperature at depth from 3 to 10 km provided by Southern Methodist University Geothermal Laboratory (Blackwell & Richards 2009) and analyses (for regions with temperatures ≥ 150°C) performed by NREL (2009).
Source data for identified hydrothermal sites from USGS Assessment of Moderate- and High-Temperature Geothermal Resources of the United States (2008).
*"N/A" regions have temperatures less than 150 C at 10 km depth and were not assessed for deep EGS potential.
**Temperature at depth data for deep EGS in Alaska and Hawaii not available.

Source: NREL, October 13, 2009.

regional variations as well as the fact that they change regularly.[23]

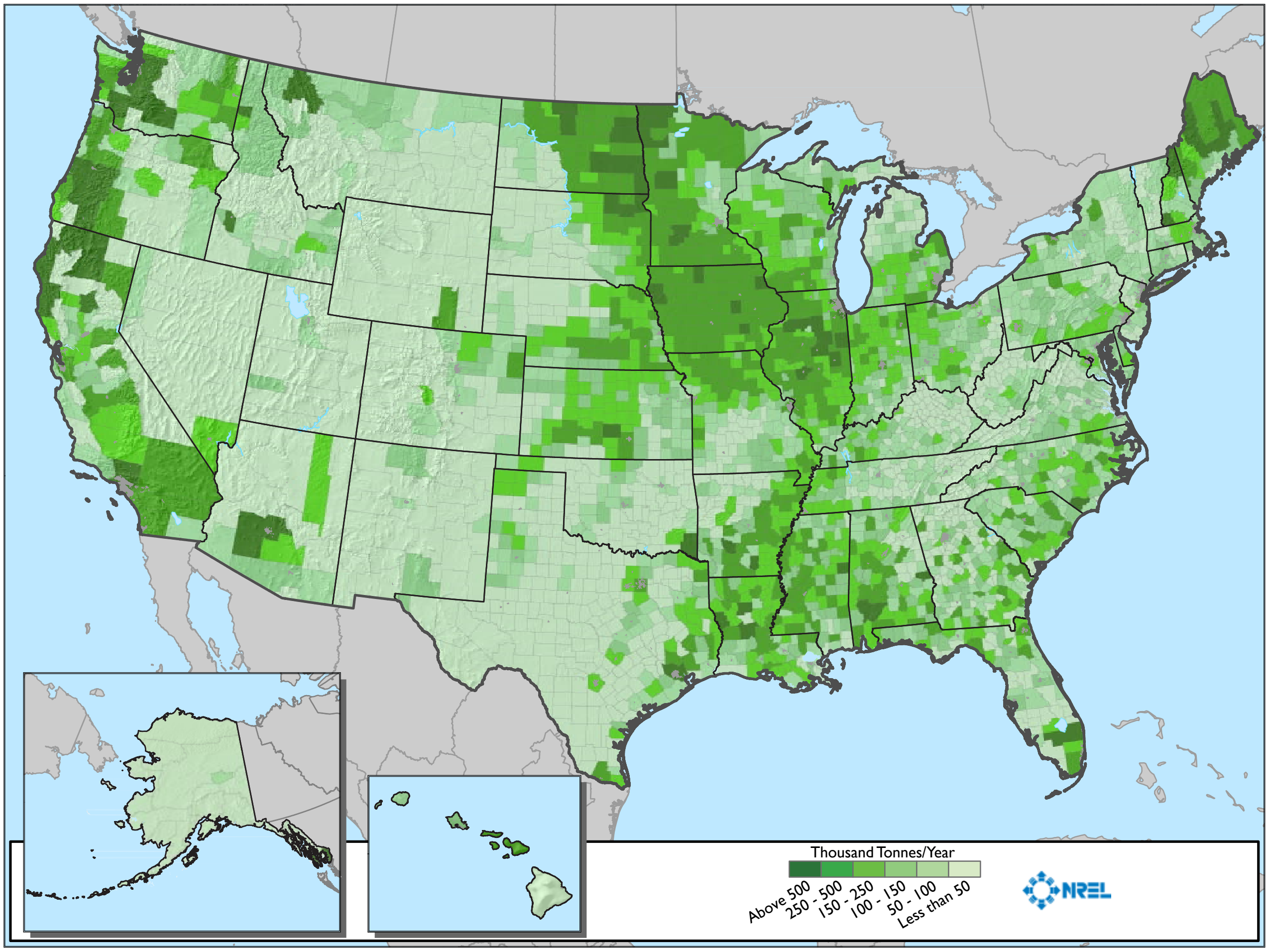
Other factors that must be considered in addition to the LECs of any given, specific project include the existing resource mix, or the energy technologies that already exist in the area that the new project would service. For example, if wind power were developed in an area that utilizes natural gas as an energy resource, it would likely have a greater value than in an area where coal is mainly used, assuming that the costs of operating the coal plant would be lower than those of operating the gas plant in that area.[24]

Another factor outside the consideration of LECs is the capacity value of a project. This means how much effective capacity a project can contribute to an area. Projects that are flexible and able to ramp up generation to meet varying energy demands have greater capacity value than projects that rely on intermittent sources of power, such as wind.[25]

Yet another factor for consideration outside of the LECs is the portfolio diversification that investors or plant owners may value, considering other projects they have or are developing. In other words, given the uncertainty concerning energy policies, prices, technologies, etc., those developing new energy resources often want to consider spreading their risk by having a variety of energy resources in their portfolio. In sum, LECs are a tool for comparing the costs of new energy generation. Yet these costs should be weighed in the specific contexts in which the given energy project under consideration will be deployed.[26]

The final major factor to consider that is beyond the scope of the EIA LECs presented in Figure 11 are the government policies enacted to promote, encourage and subsidize certain forms of energy production. These policies can be decisive in determining whether a project is economically viable for investors, power companies or individuals. Therefore, a discussion of the state and national policies relevant for renewables will follow the discussion of costs.[27]

Figure 9: U.S. Biomass Resources, Thousands of Tons Per County Per Year



Note: This map estimates the technical biomass resources currently available in the United States by county. It includes: agricultural residues (crops and animal manure); wood residues (forest, primary mill, secondary mill, and urban wood); municipal discards (methane emissions from landfills and domestic wastewater treatment); and dedicated energy crops (switchgrass on Conservation Reserve Program lands).

Source: NREL, January 23, 2008.

Comparing Costs

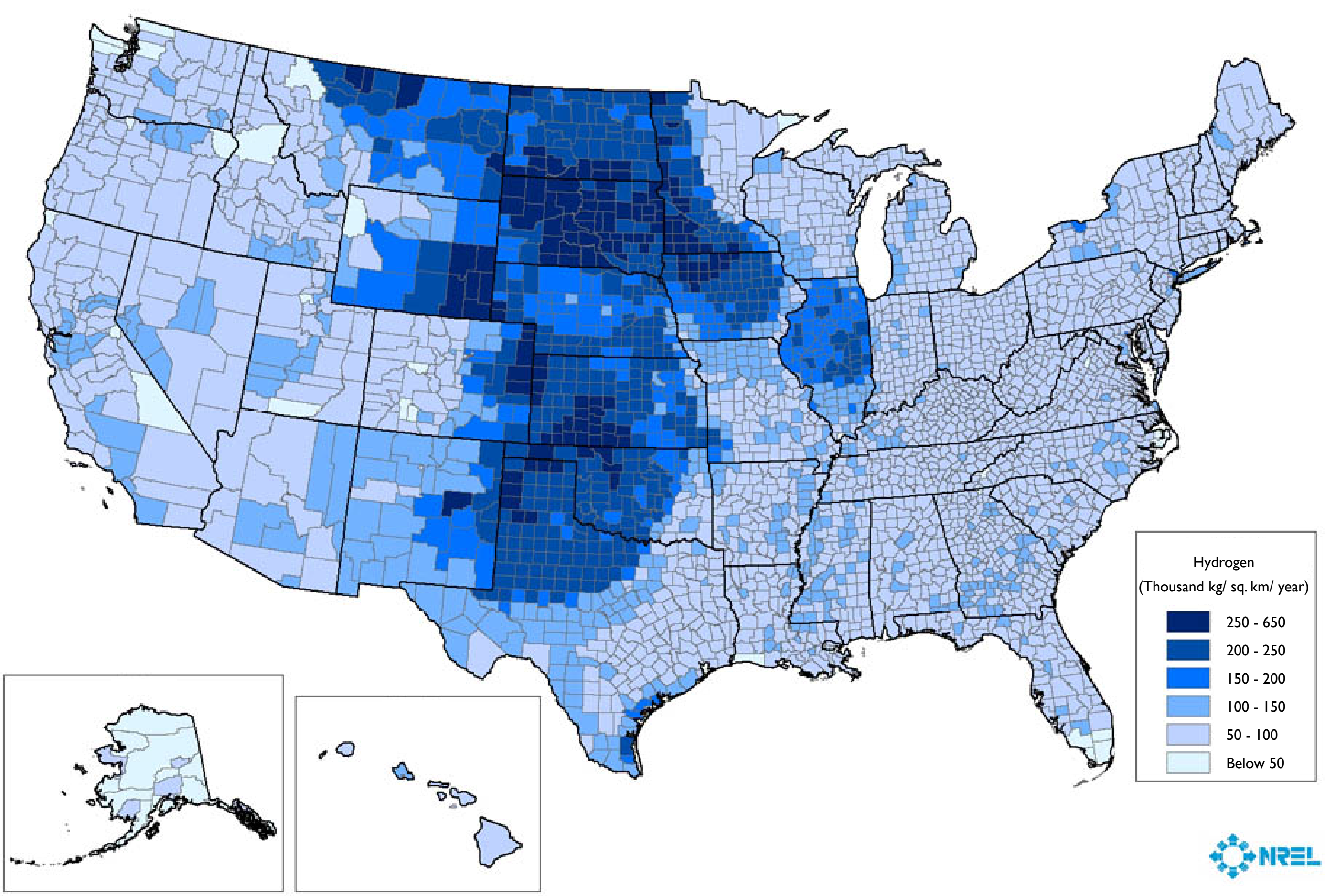
Having explained what is not included in the LECs, this report will now discuss what factors are included and what other assumptions are made. In addition to assuming a 30-year cost-recovery period for projects, these LECs assume a weighted cost-of-capital of 7.4%. Furthermore, an additional 3% cost-of-capital is added to greenhouse gas-intensive technologies without carbon capture and sequestration technologies (a way of preventing carbon dioxide emissions from escaping into the atmosphere), such as regular coal-fired plants. This 3% reflects the potential rise in costs of greenhouse gas emissions that could become subject to taxes and fees, with 3% being reflective of the additional costs normally assumed in industry calculations. Data for the 2011 LECs generated by the EIA are derived from 2009 price data, and are thus sensitive to the drop in, for example, solar panel prices in the past few years.[28]

The factors considered directly in calculating these LECs include the capacity factor, which is basically how much of the time a plant can be ready and available to provide energy. This varies for several reasons. First, some plants are in need of maintenance and service that require shutting them down for periods of time. Other plants, such as wind farms and solar plants, depend on the wind blowing or the sun shining; such plants also do not necessarily come online when the power company operators most need them and so, in this way, their LECs are not always directly comparable with other resources. The capacity factors in these LECs reflect the maximum availability of the respective resources averaged over a year's time.[29]

The costs shown in Figure 11 are national averages. There can be significant local variation in these depending on factors such as local labor markets and the costs and availability of fuel or energy resources in a given location, such as having sufficiently windy or sunny sites for wind farms and solar plants.[30]

In addition to capital costs and fixed and variable O&M, the final cost considered by the LECs is the cost of investing in new transmission. This is significant, particularly in cases where a plant must a) be located close to an energy resource (such as a wind farm), and b) the location of the plant is a significant distance from the electrical grid into which it will feed electricity. Thus, resources such as off-shore wind will usually have higher transmission costs than, for example, coal-fired power plants, which can be built closer to the grid and have coal transported to them.[31]

Figure 10: Hydrogen Potential From Renewable Resources, Total kg of Hydrogen per County Normalized by County Area



Note: This analysis shows hydrogen potential from combined renewable resources - wind, solar, and biomass. Select environmental and land use exclusions were applied.

Source: NREL, April 2006.

There is broad variation in the LECs for all resources, both between renewables and fossil-fuel resources, as well as within renewables. While some renewables, such as off-shore wind (LEC $243/MWh) and solar thermal ($312/MWh), are more costly than most other resources, some, such as land-based wind ($97/MWh), rival conventional coal ($95/MWh) before subsidies are even taken into account. Geothermal, biomass and hydro also compare favorably with coal. Overall, while it is clear that natural gas is the least expensive resource ($63-66/MWh), and off-shore wind and solar are more costly, the remaining renewables are well-placed, in terms of LECs, to compete with coal, nuclear, and advanced and CCS natural gas.[32]

Addressing the renewables individually, land-based and off-shore wind have a clear cost differential. This arises from the much greater capital costs associated with off-shore wind and the greatest amount of transmission investment of the resources in this analysis. This is to be expected with off-shore wind, as it is removed from other power plants and the electrical grid. Fixed O&M for off-shore wind is also high. Compared to most other resources, including most other renewable resources, the capacity factor of wind is relatively low, meaning it is not ready and able to contribute power to the grid as often as other resources, being essentially online only 34% of the time. On the other hand, wind has no variable O&M, due to not requiring any fuel.[33]

As a whole, solar power is the most expensive resource, with solar thermal being particularly costly. The capital costs, transmission investment, and fixed O&M for solar thermal are among the highest among resources, with the latter being likely due to the moving parts associated with the calibrated mirrors that move with the motion of the sun to reflect the maximum light. Solar photovoltaics are somewhat less costly in most areas, but capital costs are still high. Like wind, solar has a low capacity factor, 25% for solar photovoltaics and 18% for solar thermal, depending on the location. As with wind, however, solar has the advantage of having no fuel costs and no variable O&M.[34]

Geothermal power, on the other hand, has a high capacity factor, not only among renewables, but among all resources, at 92%, besting even nuclear. While capital costs and fixed O&M are relatively high, variable O&M and transmission investments are very low.[35]

Along with geothermal, biomass is another high-capacity factor resource, which also has the lowest capital costs among renewables. While fixed O&M is lower than most other renewable resources, variable O&M is higher, likely due to the need for constant supplies of biomass fuel.[36]

Finally, hydroelectric power, with the lowest LEC among renewables, also compares favorably with all other resources with the exception

Figure 11: US Average Levelized Costs (2009 $/MWh) for Plants Entering Service in 2016 - 30-Year Cost-Recovery Period

Plant Type	Capacity Factor	Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85%	$65.30	$3.90	$24.30	$1.20	$94.80
Advanced Coal	85%	74.60	7.90	25.70	1.20	109.40
Advanced Coal w/ CCS	85%	92.70	9.20	33.10	1.20	136.20
Natural Gas-fired						
Conventional Combined Cycle	87%	17.50	1.90	45.60	1.20	66.10
Advanced Combined Cycle	87%	17.90	1.90	42.10	1.20	63.10
Advanced Combined Cycle w/ CCS	87%	34.60	3.90	49.60	1.20	89.30
Conventional Combustion Turbine	30%	45.80	3.70	71.50	3.50	124.50
Advanced Combustion Turbine	30%	31.60	5.50	62.90	3.50	103.50
Advanced Nuclear	90%	90.10	11.10	11.70	1.00	113.90
Wind	34%	83.90	9.60	0.00	3.50	97.00
Wind - Offshore	34%	209.30	28.10	0.00	5.90	243.20
Solar Photovoltaics*	25%	194.60	12.10	0.00	4.00	210.70
Solar Thermal	18%	259.40	46.60	0.00	5.80	311.80
Geothermal	92%	79.30	11.90	9.50	1.00	101.70
Biomass	83%	55.30	13.70	42.30	1.30	112.50
Hydro	52%	74.50	3.80	6.30	1.90	86.40

*Net AC power to grid from installed capacity.

Source: Energy Information Administration's Annual Energy Outlook 2011.

of some forms of natural gas. This is because of low capital costs, low fixed and variable O&M, low transmission investments, and a decent capacity factor by renewable standards.[37]

Despite the usefulness of LECs in comparing the different prospects for new electricity generation from different sources, there are three main limitations. First, prices for fuel, capital and O&M vary with time, as does technology. For example, as mentioned earlier, the price of solar has been dropping drastically in recent months and years. The second limitation is that local circumstances will likely play a decisive role in determining how a given resource fits into the local energy market, given both the existing resource mix, and the availability of the resource—for example the wind required for a wind farm—in the local area. Third, there are political barriers to the development of all resources, not just fossil fuel-based ones. For example, there has been opposition to the development of wind farms in some locales on the basis that they create an eyesore, generate noise pollution, and create a hazard for birds that fly through wind farm areas.

In order to get a better sense of local circumstances, the EIA has also applied NEMS to determine the range of regional variation among LECs for the different energy resources. While this does not project LECs for any specific region, it does give a sense of how prices can vary among the regions. Unfortunately, while some states, such as California, have modeled their own, state-specific LECs, it appears that Utah has not done so. Therefore, the regional LECs shown in Figure 12, while more general, give the best sense of what Utah could expect in terms of costs for different energy resources, absent situation- and resource-specific analyses.

Figure 12 reveals that there are significant variations among the costs of resources, especially among renewable resources. This is to be expected as certain regions of the country are much more amenable to certain types of renewables, by virtue of their geology, climate and weather patterns. For example, solar power would be much more effective in Arizona than in the Pacific Northwest, where there is significant cloud cover much of the time. Solar power has the most pronounced differences in costs, with solar thermal being potentially three times as expensive in some areas of the country than others. Off-shore wind also has a significant difference in costs, as does hydroelectric power to some extent. Geothermal, biomass and land-based wind have less variation.[38]

The LECs presented in Figure 12 are one way of looking at the costs of deploying different sources of power generation, including renewables. These various costs are ultimately borne by the consumers of the electricity produced. Therefore, generally speaking, higher-cost sources of energy will result in higher costs of electricity to the individuals, companies and others that consume it. However, policies that subsidize or use laws and regulations to encourage the building of and generation of energy from certain energy resources can mitigate these costs to consumers through the use of tax dollars and legal instruments. The national- and state-level policies that affect renewables are therefore presented in Figures 14 and 15.

U.S. Renewable Energy Policies

Although Renewable Portfolio Standards (RPS) are actually state-level policies, they are placed in this section because they are comparable across states and information is available for them at the general level. Figure 13 details the RPS mandates for states that have current mandates. These mandates differ in type, with some having much more ambitious targets for renewable generation than others. Also differing among RPS are whether the targets are general or resource-specific, the latter requiring not only an overall renewable target, but also specifying which renewables will be used and to what extent. Utah has no current RPS mandates, along with 19 other states. Rather, in 2008, then-Governor Jon Huntsman signed into law a voluntary renewable portfolio goal encouraging utilities to produce 20% of their energy from renewable resources by 2025. At the request of the legislature, the goal stipulated that utilities pursue "cost-effective" renewable energy.[39]

Figure 12: Regional Variation in Levelized Cost of New Generation Resources (2009 $/MWh) for Plants Entering Service in 2016 - Range of Total System Levelized Costs

Plant Type	Minimum	Average	Maximum
Conventional Coal	$85.50	$94.80	$110.80
Advanced Coal	100.70	109.40	122.10
Advanced Coal w/ CCS	126.30	136.20	154.50
Natural Gas-fired			
Conventional Combined Cycle	60.00	66.10	74.10
Advanced Combined Cycle	56.90	63.10	70.50
Advanced Combined Cycle w/ CCS	80.80	89.30	104.00
Conventional Combustion Turbine	99.20	124.50	144.20
Advanced Combustion Turbine	87.10	103.50	118.20
Advanced Nuclear	109.70	113.90	121.40
Wind	81.90	97.00	115.00
Wind - Offshore	186.70	243.20	349.40
Solar Photovoltaics*	158.70	210.70	323.90
Solar Thermal	191.70	311.80	641.60
Geothermal	91.80	101.70	115.70
Biomass	99.50	112.50	133.40
Hydro	58.50	86.40	121.40

*Net AC power to grid from installed capacity.

Source: Energy Information Administration's Annual Energy Outlook 2011.

Given the state of the national and global economy, there are questions of how realistic the RPS of states are and how well states will be able to meet them. This is because renewable energy tends to cost more, sometimes much more, than traditional sources of electricity. States often offer incentives, including subsidies, to both individuals and utilities to develop renewable energy resources in order to meet their RPS targets, but with tightened budgets, states' ability to do this might be constrained. On the other hand, as is evident from the RPS of states nearby Utah such as California, Nevada, Colorado, Arizona and New Mexico, some strategically located states, including Utah, might have the potential to profit from RPS in other states by developing renewable energy for export to states with renewable mandates.

In addition to the state-level RPS, the federal government offers incentives and has policies in place to encourage the development, installation and use of renewable energy resources. Utah Foundation has compiled a basic overview of the various incentives in Figure 14. The incentives outlined here are those that are most generally applicable.

As is evident in Figure 14, there are several types of financial incentives offered by the federal government for the development, installation and use of renewable energy technologies. These incentives shift the economics more in favor of renewables by effectively reducing the costs of renewable energy to producers and consumers. Whether a given incentive or collection of incentives is enough to justify the price of developing, installing and using renewables depends on how much the costs of purchasing and installing the renewable equipment itself—which varies and, in most cases, is falling over time—are outweighed by the incentives, cost savings of operating the equipment compared to traditional equipment, benefits to the environment, and, for companies, the benefits to their public image for being certified, labeled, or perceived as "green," "ecological," or "sustainable." Many individuals and companies have done the calculus and concluded that the costs are worth it, given the incentives and other benefits. But this calculation is a moving target, changing over time as the market for renewables changes. The availability of incentives is also constantly in flux, with some programs being fully subscribed—i.e., not able to accept new applications—and some programs being in a state of uncertain and

Figure 13: Renewable Portfolio Standards in the 30 States with Current Mandates

AZ	Arizona Corporate Commission Decision No. 69127 requires 15% of electricity sales to be renewable by 2025, with interim goals increasing annually. A specific percentage of the target must be from distributed generation. Multiple credits may be provided to solar generation and systems manufactured in-State.
CA	As a follow-up from AB 32 and Executive Order S-21-09, the CARB now administers a new RPS that requires 33% renewable generation by 2020.
CO	Enacted in March 2010, House Bill (HB) 1001 strengthens the State's existing RPS program by requiring 20% of electricity generated by investor-owned utilities in 2015 to be renewable, increasing to 30% by 2020. There is also a distributed generation requirement. In-State generation receives a 25% credit premium.
CT	Public Act 07-242 mandates a 27% renewable sales requirement by 2020, including a 4% requirement for sales from higher efficiency or combined heat and power systems. Of the overall total, 3% may be met by waste-to-energy and conventional biomass facilities.
DE	Senate Substitute 1 amended Senate Bill 119 to extend the increasing RPS targets to 2025; 25% of generation is now required to come from renewable sources in 2025. There is a separate requirement for solar generation (3.5% of the total in 2025) and penalty payments for compliance failure. Offshore wind receives 3.5 times the standard credit amount.
HI	HB 1464 sets the renewable mandate at 40% by 2030. All existing renewable facilities are eligible to meet the target, which has two interim milestones.
IL	Public Act 095-0481 created an agency responsible for overseeing the mandate of 25% renewable sales by 2025, with escalating annual targets. In addtion, 75% of the required sales must be generated from wind and 6% from solar. The plan also includes a cap on incremental costs resulting from the penetration of renewable generation. In 2009, the rule was modified to cover sales outside a utility's home territory.
IA	In 1983, an RPS mandating 105 megawatts of renewable energy capacity was adopted.
KS	In 2009, HB 2369 established a requirement that 20% of installed capacity must use renewable resources by 2020.
ME	In 2007, Public Law 403 was added to the State's RPS requirements. The law requires a 10% increase from the 2006 level of renewable capacity by 2017, and that level must be maintained in subsequent years. The years leading up to 2017 also have new capacity milestones. Generation from eligible community-owned facilities receives a 10% credit premium.
MD	In April 2008, HB 375 revised the preceding RPS to include a target of 20% renewable generation by 2022, including a 2% solar target. HB 375 also raised penalty payments for "Tier 1" compliance shortfalls to 4 cents per kilowatthour. Senate Bill 277, while preserving 2022 target of 2% solar, made the interim solar requirements and penalty payments slightly less stringent.
MA	The State RPS has a goal of a 15% renewable share of total sales by 2020 and includes necessary payments for compliance shortfalls. Eligible biomass is restricted to low-carbon life cycle emission sources. A Solar Carve-Out Program was also added, which seeks to establish 400 megawatts (DC) of solar generating capacity.
MI	Public Act 295 established an RPS that will require 10% renewable generation by 2015. Bonus credits are given to solar energy.
MN	Senate Bill 4 created a 30% renewable requirement by 2020 for Xcel, the State's largest supplier, and a 25% requirement by 2025 for other suppliers. The 30% requirement for Xcel consists of 24% that must be from wind, 1% that can be from wind or solar, and 5% that can be from other resources.
MO	In November 2008, Missouri voters approved Proposition C, which mandates a 2% renewable energy requirement in 2011, increasing incrementally to 15% of generation in 2021. Bonus credits are given to renewable generation within the State.
MT	HB 681, approved in April 2008, expanded the State RPS provisions to all suppliers. Initially the law covered only public utilities. A 15% share of sales must be renewable by 2015. The State operates a renewable energy credit market.
NV	The State has an escalating renewable target, established in 1997 and revised in 2005 and again in 2009 by Senate Bill 358. The most recent requirement mandates a 25% renewable generation share of sales by 2025. Up to one-fourth of the 25% share may be met through efficiency measures. There is also a minimum requirement for PV systems, which receive bonus credits.
NH	HB 873, passed in May 2007, legislated that 23.8% of electricity sales must be met by renewables in 2025. Compliance penalties vary by generation type.
NJ	In 2006, the State RPS was revised to increase renewable energy targets. Renewable generation is to provide 22.5% of sales by 2021, with interim targets. AB 3520 requires 5,316 gigawatthours of solar generation by 2026. SB 2036 has a specific offshore wind target of 1,100 megawatts of capacity.
NM	Senate Bill 418, passed in March 2007, directs investor-owned utilities to derive 20% of their sales from renewable generation by 2020. The renewable portfolio must consist of diversified technologies, with wind and solar each accounting for 20% of the target. There is a separate standard of 10% by 2020 for cooperatives.
NY	The Public Service Commission issued updated RPS rules in January of 2010, expanding the program to a 29% requirement by 2015. There is also a separate end-use standard. The program is administered and funded by the State.
NC	In 2007, Senate Bill 3 created an RPS of 12.5% by 2021 for investor-owned utilities. There is also a 10% requirement by 2018 for cooperatives and municipals. Through 2018, 25% of the target may be met through efficiency standards, increasing to 40% in later years.
OH	Senate Bill 221, passed in May 2008, requires 25% of electricity sales to be produced from alternative energy resources by 2025, including low-carbon and renewable technologies. One-half of the target must come from renewable sources. Municipals and cooperatives are exempt.
OR	Senate Bill 838, signed into law in June 2007, required renewable targets of 25% by 2025 for large utilities and 5 to 10% by 2025 for smaller utilities. Renewable electricity on line after 1995 is considered eligible.
PA	The Alternative Energy Portfolio Standard, signed into law in November 2004, has an 18% requirement by 2020. Most of the qualifying generation must be renewable, but there is also a provision that allows waste coal resources to receive credits.
RI	The Renewable Energy Standard was signed into law in 2004. The program requires that 16% of total sales be renewable by 2019. The interim program targets escalate more rapidly in later years. If the target is not met, a generator must pay an alternative compliance penalty. State utilities must also procure 90 megawatts of new renewable capacity, including 3 megawatts of solar, by 2014.
TX	Senate Bill 20, passed in August 2005, strengthened the State RPS by mandating 5,880 megawatts of renewable capacity by 2015. There is also a target of 500 megawatts of renewable capacity other than wind.
WA	In November 2006, Washington voters approved Initiative 937, which specifies that 15% of sales from the State's largest generators must come from renewable sources by 2020. There is an administrative penalty of 5 cents per kilowatthour for noncompliance. Generation from any facility that came on line after 1999 is eligible.
WV	HB 103, passed in June 2009, established a requirement that 25% of sales must come from alternative energy resources by 2025. Alternative energy was defined to include various renewables, along with several different fossil energy technologies.
WI	Senate Bill 459, passed in March 2006, strengthened the State RPS with a requirement that, by 2015, each utility must generate 10% of its electricity from renewable resources, up from the previous requirement of 2.2% in 2011. The renewable share of total generation must be at least 6 percentage points above the average renewable share from 2001 to 2003.

Source: Energy Information Administration's Annual Energy Outlook 2011.

Figure 14: Federal Incentives for Renewable Energy

Incentive Type	Description	Applicable Sectors	Eligible Technologies	Amount
Corporate Depreciation	Bonus depreciation of value of renewable energy investments to decrease tax liability	Commercial, Industrial, Agricultural	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Geothermal Electric, Fuel Cells, Geothermal Heat Pumps, Municipal Solid Waste, CHP/Cogeneration, Solar Hybrid Lighting, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines, Geothermal Direct-Use	50-100% bonus depreciation
Corporate Exemption	Tax exemption for conservation subsidies provided by renewable technologies	Residential, Multi-Family Residential	Solar Water Heat, Solar Space Heat, Photovoltaics	100% of conservation subsidies are non-taxable
Corporate Tax Credit	Tax credit for installation of renewable energy	Commercial, Industrial, Utility, Agricultural	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Wind, Biomass, Geothermal Electric, Fuel Cells, Geothermal Heat Pumps, CHP/Cogeneration, Solar Hybrid Lighting, Fuel Cells using Renewable Fuels, Microturbines, Geothermal Direct-Use	30% for solar, fuel cells and small wind 10% for geothermal, microturbines and CHP Fuel cells: $1,500 per 0.5 kW Microturbines: $200 per kW Small wind turbines placed in service 10/4/08 - 12/31/08: $4,000 Small wind turbines placed in service after 12/31/08: no limit All other eligible technologies: no limit
Corporate Tax Credit	Tax credit for production of renewable energy	Commercial, Industrial	Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Hydrokinetic Power (i.e., Flowing Water), Anaerobic Digestion, Small Hydroelectric, Tidal Energy, Wave Energy, Ocean Thermal	2.2¢/kWh for wind, geothermal, closed-loop biomass 1.1¢/kWh for other eligible technologies
Federal Grant Program	Grants for financing development of renewable energy resources	Commercial, Industrial, Agricultural	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Fuel Cells, Geothermal Heat Pumps, Municipal Solid Waste, CHP/Cogeneration, Solar Hybrid Lighting, Hydrokinetic, Tidal Energy, Wave Energy, Ocean Thermal, Fuel Cells using Renewable Fuels, Microturbines	30% of property that is part of a qualified facility, qualified fuel cell property, solar property, or qualified small wind property; 10% of all other property Maximum incentives: $1,500 per 0.5 kW for qualified fuel cell property $200 per kW for qualified microturbine property 50 MW for CHP property, with limitations for large systems
Federal Loan Program	Clean renewable energy bonds to finance renewable energy projects	Local Government, State Government, Tribal Government, Municipal Utility, Rural Electric Cooperative	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Hydrokinetic Power, Anaerobic Digestion, Tidal Energy, Wave Energy, Ocean Thermal	Varies
Federal Loan Program	Add up to 100% of energy improvements to a mortgage loan	Residential	Passive Solar Space Heat, Solar Water Heat, Solar Space Heat, Photovoltaics, Daylighting	5% of the value of the property
Federal Loan Program	Federal loans to state and local governments for renewable energy investments	Local Government, State Government, Tribal Government	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Municipal Solid Waste, Hydrokinetic Power, Anaerobic Digestion, Tidal Energy, Wave Energy, Ocean Thermal	Varies
Federal Loan Program	Federally issued loan guarantees for financing development of renewable and emissions-reducing technologies	Commercial, Industrial, Nonprofit, Schools, Local Government, State Government, Agricultural, Institutional, Any non-federal entity, Manufacturing Facilities	Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Wind, Hydroelectric, Geothermal Electric, Fuel Cells, Daylighting, Tidal Energy, Wave Energy, Ocean Thermal, Biodiesel, Fuel Cells using Renewable Fuels	Varies Program focuses on projects with total project costs over $25 million
Performance-Based Incentive	Renewable energy production incentive	Local Government, State Government, Tribal Government, Municipal Utility, Rural Electric Cooperative, Native Corporations	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Geothermal Electric, Anaerobic Digestion, Tidal Energy, Wave Energy, Ocean Thermal	2.2¢/kWh
Personal Exemption	Tax exemption for conservation subsidies provided by renewable technologies	Residential, Multi-Family Residential	Solar Water Heat, Solar Space Heat, Photovoltaics	100% of conservation subsidies are non-taxable
Personal Tax Credit	Tax credit for installation of renewable energy	Residential	Biomass, Stoves that use qualified biomass fuel	For purchases made in 2011: aggregate amount of credit is limited to $500 Taxpayer is ineligible for this tax credit if this credit has already been claimed by the taxpayer in an amount of $500 in any previous year For purchases made in 2009 or 2010, 30%: aggregate amount of credit for all technologies placed in service in 2009 and 2010 combined is limited to $1,500
Personal Tax Credit	Tax credit for installation of renewable energy	Residential	Solar Water Heat, Photovoltaics, Wind, Fuel Cells, Geothermal Heat Pumps, Other Solar Electric Technologies, Fuel Cells using Renewable Fuels	30% of value Maximum incentives: solar-electric systems placed in service before 1/1/2009: $2,000 Solar-electric systems placed in service after 12/31/2008: no maximum Solar water heaters placed in service before 1/1/2009: $2,000 Solar water heaters placed in service after 12/31/2008: no maximum Wind turbines placed in service in 2008: $4,000 Wind turbines placed in service after 12/31/2008: no maximum Geothermal heat pumps placed in service in 2008: $2,000 Geothermal heat pumps placed in service after 12/31/2008: no maximum Fuel cells: $500 per 0.5 kW

Source: Database of State Incentives for Renewables and Efficiency.

Figure 15: State of Utah Incentives for Renewable Energy

Incentive Type	Description	Applicable Sectors	Eligible Technologies	Amount
Corporate Tax Credit	Tax credit for installation of renewable energy	Commercial, Residential, Construction, Installer/Contractor, Multi-Family Residential	Passive Solar Space Heat, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Geothermal Heat Pumps, Solar Pool Heating, Anaerobic Digestion, Geothermal Direct-Use	Residential: 25% Commercial wind, geothermal electric, and biomass systems 660 kW or greater: 0.35¢/kWh ($0.0035/kWh) for 4 years Other commercial systems: 10%
Industry Recruitment/ Sipport	Incentives for renewable technology companies that locate in Utah	Commercial, Industrial	Solar Thermal Electric, Photovoltaics, Wind, Biomass, Hydroelectric, Geothermal Electric, Other Non-Renewable Alternative Energy Resources (see summary for list), Small Hydroelectric	Determined on a case-by-case basis by the Governor's Office of Economic Development Board and Executive Director based on statutory guidelines and evaluation criteria Up to 100% of new state tax revenues (including, state, corporate, sales and withholding taxes) over the life of the project (typically 5-10 years)
Personal Tax Credit	Tax credit for installation of renewable energy	Commercial, Residential, Multi-Family Residential	Passive Solar Space Heat, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Geothermal Heat Pumps, Solar Pool Heating, Anaerobic Digestion, Geothermal Direct-Use	Residential: 25% Commercial wind, geothermal electric, and biomass systems 660 kW or greater: 0.35¢/kWh ($0.0035/kWh) for 4 years Other commercial systems: 10% Residential: $2,000 Commercial wind, geothermal electric, and biomass systems 660 kW or greater: no limit Other commercial systems: $50,000
Sales Tax Incentive	Sales tax exemption on purchase or lease of renewable generation equipment	Commercial, Industrial, Utility	Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydroelectric, Geothermal Electric, Anaerobic Digestion	100% of sales taxes
State Rebate Program	Rebates on purchase of renewable energy systems	Commercial, Residential, Nonprofit, Schools	Solar Water Heat, Photovoltaics, Wind	PV: $1.50/W DC Solar Water Heating: $40/sq ft net aperture (SRCC) Wind: $1.00/W PV (residential): lesser of 25% of eligible cost or $4,500 PV (non-residential): lesser of 25% of eligible cost or $25,000 Solar water heating (residential): lesser of 25% of eligible costs or $2,500 Solar water heating (non-residential): lesser of 25% of eligible cost or $10,000 Wind (residential): lesser of 25% of eligible cost or $2,500 Wind (non-residential): lesser of 25% of eligible cost or $2,500
Questar Gas Utility Rebate Program	Rebates on purchases of renewable energy systems	Residential, Construction, Multi-Family Residential	Solar Water Heat, Solar Pool Heating	750
Rocky Mountain Power Utility Rebate Program	Cash incentives for contractors who build energy-efficient homes	Residential, Construction, Installer/Contractor, Multi-Family Residential	Geothermal Heat Pumps	ENERGY STAR Single-Family Home: $250-$300/home ENERGY STAR Federal Tax Credit Certified Single-family home: $800/home ENERGY STAR Home including well-based ground source heat pump: $2,000 ENERGY STAR Multifamily Housing: $200-$300/unit
Rocky Mountain Power Utility Rebate Program	Rebate on installation of renewable energy systems	Commercial, Industrial, Residential, Nonprofit, Schools, Local Government, State Government, Fed. Government	Photovoltaics	$1.55 per watt AC; max incentive: residential: $4,650; non-residential: $23,250

Source: Database of State Incentives for Renewables and Efficiency.

threatened funding, or facing expiration, factors which are dependent on federal budgets and politics.

In addition to the incentives described above, the federal government has implemented other policies related to encouraging renewable energy. Most are of a regulatory nature, but, notably, the federal government has committed to increase the amount of energy it consumes from renewable resources to 7.5% of its total energy consumption from fiscal year 2013 and onward and the Department of Defense has committed to produce or procure 25% of its energy from renewable resources by 2025. This later policy could have a significant impact on Utah's renewable energy consumption due to the military presence in the state.[40]

Utah's Renewable Energy Policies

The Utah state government offers incentives and has policies in place to encourage the development, installation, and use of renewable energy resources. Utah Foundation has compiled a basic overview of the various incentives. The incentives outlined in Figure 15 are those that are most generally applicable.

As with federal incentives, state incentives are targeted at providing financial motivation for individuals and organizations to develop, install and use renewable energy technologies. Also, as with federal programs, some are subject to funding and budget constraints. In addition to these incentives, Utah also has policies for easements and metering, which favor renewable energy. Easements may be granted to individuals and companies installing renewables so that they can enter voluntary contracts with other parties, for example neighbors, to secure access to sunlight for the solar panels they have installed, meaning that no future buildings or structures may obstruct that sunlight. Net metering, on the other hand, is a policy that ensures that utilities credit the amount of electricity produced by an individual's or company's installed renewable technologies to the individual's or company's electrical bill.

Other LECs

As mentioned earlier, public policies can be decisive in determining whether it makes financial sense for an individual, business, power company or investor to finance the development and production of electricity from a given energy resource. Therefore, it can be

Figure 16: Lazard LECs

Plant Type	Total System Levelized Cost ($/MWh)
Coal	$70-$152
Advanced Coal	97-126
Natural Gas-fired	69-97
Nuclear	77-113
Wind	30-79
Wind - Offshore	164
Solar PV	89-192
Solar Thermal	120-198
Geothermal	73-135
Biomass	81-136

Source: Levelized Cost of Energy Analysis – Version 5.0. Lazard. June 2011.

beneficial to consider how the costs of different sources of power are affected by these policies.

Figure 16 shows a set of LECs calculated by Lazard, a financial and investment advisory firm. Incorporated in these LECs are the relevant federal investment and production tax credits that apply to various energy resources. While it is beneficial on the one hand to view the effects of such credits on costs, it is also possible that such subsidies will not be available or funded in the future, due to the federal budget deficits and debates surrounding this issue. This holds true for renewable as well as fossil-fuel-based sources of energy, the latter of which faces the possibility of carbon dioxide emissions rules and other regulations. It should be noted that while the Lazard numbers include federal investment and production tax credits, they exclude other subsidies and incentives, including state-level incentives.

While the Lazard LECs use more recent data compared to the 2009 numbers used by the EIA, there are a number of assumptions that vary from those of the EIA. First, reflecting recent price drops in wind and, particularly solar power, the capital costs of building generation capacity based on these energy resources is considerably lower than the EIAs numbers. In contrast to the EIA LECs, the Lazard LECs do not include average transmission costs for various energy resources. Also, the potential benefits or costs of emissions offsets for various energy resources are not included.[41]

Other assumptions behind the Lazard LECs include assuming facilities that would come online in 2012 and have operational lives of 20 to 40 years, depending on the resource. Also, in some cases, capacity factors vary significantly from those used by the EIA, particularly for CSP (26-43% as opposed to 18% from the EIA), natural gas (40-70% compared to 87%), and advanced coal (75% as opposed to 85%). These capacity factors tend to favor renewable resources, compared to the ones used by the EIA. Finally, the Lazard LECs are given as ranges, rather than the averages used by the EIA. These ranges suggest the variability in LECs, depending on location and other factors.[42]

Compared to the EIA LECs, the Lazard LECs are not entirely dissimilar. Most EIA LECs fall within the range suggested by the Lazard LECs. However, there are some major differences for solar and wind power, which are both significantly less costly according to the Lazard LECs. Offshore wind and solar thermal (CSP) in particular are less costly. All these differences are likely primarily reflective of the major drop in capital costs in wind and solar in the past two years, but can also be attributed somewhat to the inclusion in the Lazard LECs of federal tax incentives for wind and solar.[43]

Overall, the differences in the EIA and Lazard LECs highlights the fact that LECs are only as good as their assumptions. However, the similarity between the LECs indicate that by taking them both into account, the true costs of different energy resources can be more accurately "triangulated." Viewed in this way, LECs are tools to be used to generalize about and compare the costs of various energy resources. They provide a helpful, if not definitive, indication of what the costs of energy are. As mentioned above, individual circumstances, including location, actual incentives, subsidies, contracts, leases, financing agreements, etc. will ultimately dictate the economic and financial soundness of any given project for consumers, investors, businesses and power companies.

LOOKING TOWARD THE FUTURE

Renewable energy is in a dynamic phase in its development, with new technologies being introduced, old ones refined, prices in flux, policies in motion, and investors and utilities trying to make the best investments in the future of energy resources. There are many useful tools for evaluating and comparing energy resources, but not all such measures can be quantified or even well defined. Furthermore, there is always the potential for system shocks—game changers—to come along that few could have predicted. The recent emergence of information on the abundance of natural gas in the United States, along with the development of the technologies necessary to get to and transport it relatively cheaply, have the potential to drastically alter the energy landscape of the U.S. in the future if the environmental concerns related to gas extraction can be sufficiently addressed.

On the other hand, if efforts to develop energy storage technologies mature, they could greatly affect the ability of resources such as solar and wind to provide energy to society on demand. If energy storage technologies were successfully deployed, energy produced from wind and solar resources could be stored when the wind was blowing and the sun was shining and then dispatched to the electrical grid when it would be needed most.

Until then, each energy resource has a set of costs and benefits that dictate the role it can play in the energy portfolios of power companies, states and the country. Intermittent renewables such as wind and sun serve best as a complement to existing peak demand and base load generation resources, such as coal and gas. Geothermal, biomass and hydro, on the other hand, can supplement the base load capacity of coal- and gas-fired plants. So the question of which resources are best to use in a given place is not so much one of "either renewables or fossil fuels" as it is "what combination of resources is best, given local and regional circumstances."

Add to all this the shifting politics and policies surrounding renewable energy, as well as fossil-fuel resources, and the picture gets cloudier still. What is clear, though, is that the future of energy, rather than being based on one dominant energy source, is likely to be more diverse and varied both within regions of the country, as well as among them. In other words, the menu of energy choices available to energy consumers will probably continue to grow. The question would then seem to be not so much if renewable energy will be part of the energy landscape of the future, but what role it will play.

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